NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

REPLY TO
ATTN OF: GP

March 27, 1971

TO: USI/Scientific & Technical Information Division
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General
Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned
U.S. Patents in STAR

In accordance with the procedures contained in the Code GP to Code USI memorandum on this subject, dated June 8, 1970, the attached NASA-owned U.S. patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. : 3,347,531

Corporate Source : Ames Research Center

Supplementary
Corporate Source :

NASA Patent Case No.: XAC-06956

Gayle Parker

Enclosure:
Copy of Patent

Oct. 17, 1967 I. J. STRONG ETAL 3,347,531

STIRRING APPARATUS FOR PLURAL TEST TUBES

Filed March 22, 1966 2 Sheets-Sheet 1

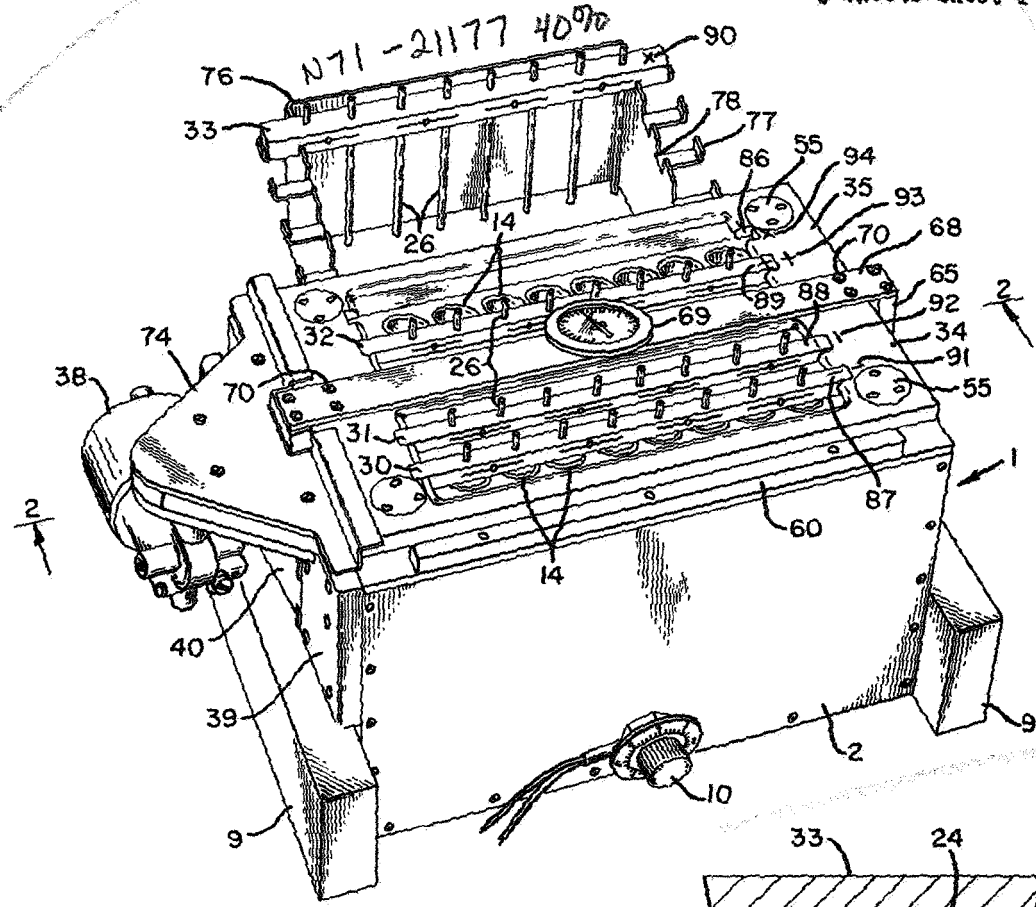

FIG-1

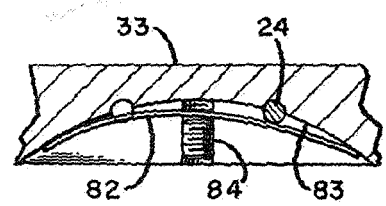

FIG-5

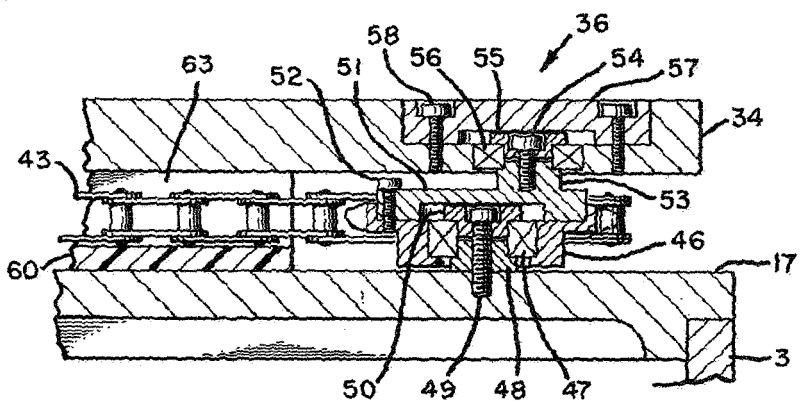

FIG-4

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STIRRING APPARATUS FOR PLURAL TEST TUBES

Filed March 22, 1966 2 Sheets-Sheet 2

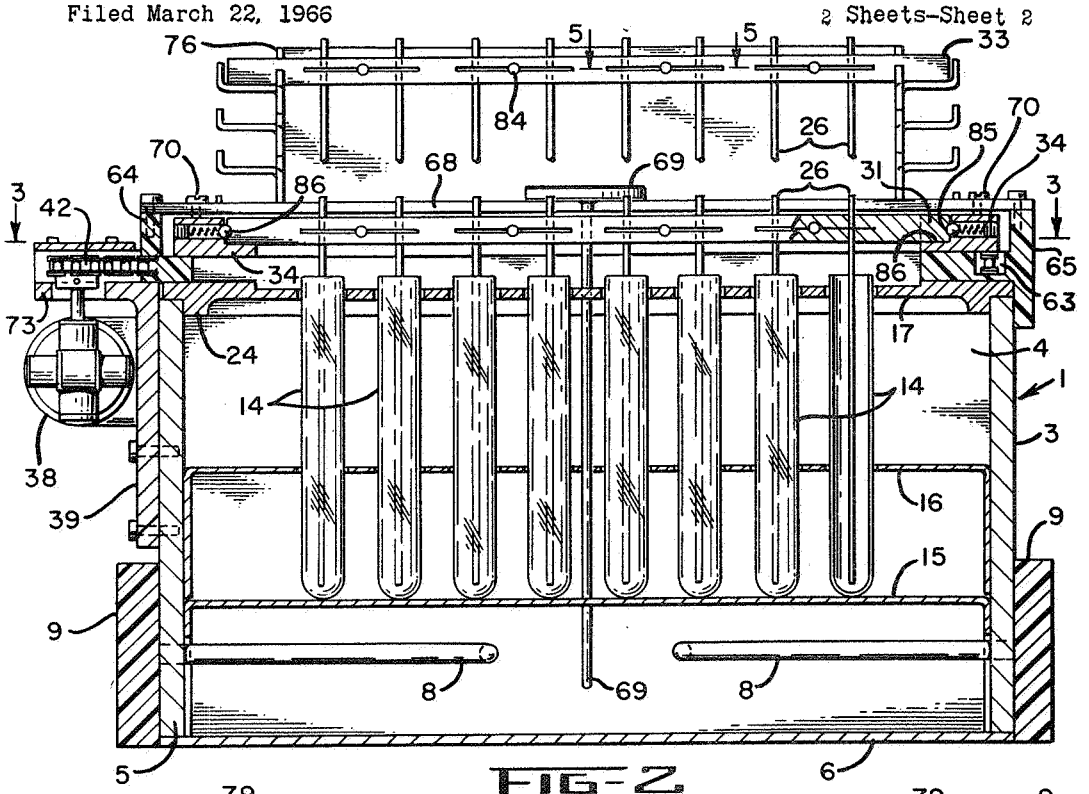

FIG-2

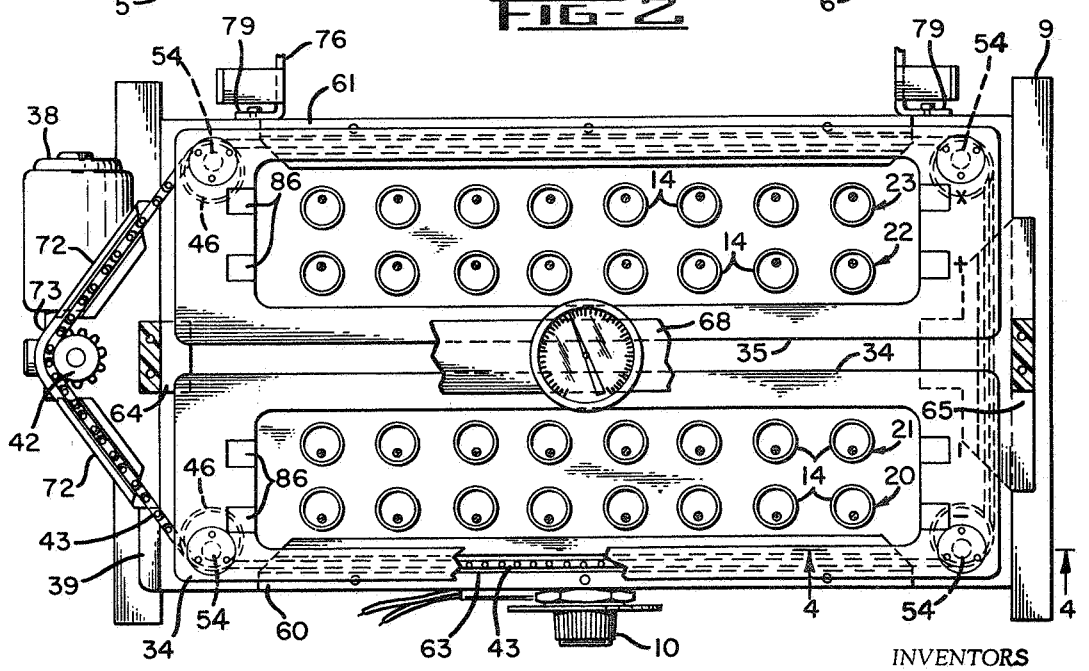

FIG-3

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Patented Oct. 17, 1967

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STIRRING APPARATUS FOR PLURAL TEST TUBES

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8 Claims. (Cl. 259—71)

ABSTRACT OF THE DISCLOSURE

A device for simultaneously agitating and thermally controlling the contents of a plurality of test tubes. Rows of test tubes are supported on a rack in a temperature-controlled bath. A rod is suspended in each tube from one of two frames. The frames and rods are oscillated at variable speeds, and in opposite directions to minimize vibration. The stirring rods are adjustable with respect to tube penetration, and they may be removed from the frames individually or by the row.

The invention described herein was made by an employee of the United States Government and may be manufactured and used by or for the Government for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to apparatus for continually stirring the contents of test tubes.

Various laboratory techniques require or could be substantially benefitted by maintaining the contents of test tubes continuously in motion throughout the period of the test. Accordingly, the primary object of the invention is to provide apparatus which will automatically and continuously stir the contents of test tubes for a desired period of time in a simple and efficient manner.

More specifically an object of the invention is to provide stirring apparatus which will accomplish the desired mixing function for a large number of test tubes in a simultaneous manner.

Another object of the invention is to accomplish the stirring function in a manner which will avoid spilling the contents of any test tube. This is accomplished by performing the stirring by means of a moving stirring rod which projects into each test tube, while maintaining the test tubes stationary. This method is to be distinguished from one of the prior methods which involved continuous shaking of the test tube which of course requires care to avoid spilling the contents out of the top of the test tube.

Another object of the invention is to provide stirring apparatus which will provide sufficient agitation to keep solids in suspension. The mentioned prior method which involves shaking the test tube is not satisfactory for maintaining solids in suspension.

A further object of the invention is to provide stirring apparatus in which the temperature of the contents of each of the test tubes can be accurately controlled throughout the stirring period.

An additional object of the invention is to provide stirring apparatus which will be capable of simultaneously stirring a large number of test tubes and yet will be substantially free of vibration.

A further object of the invention is to provide stirring apparatus having indexing means to assure that each stirring rod will be associated with a specific test tube. Thus when the stirring rods are removed from certain test tubes and later replaced in the test tubes it will be possible to be certain that each test tube receives its original stirring rod in order to avoid any cross contamination between test tubes.

Another object of the invention is to provide stirring apparatus which will accommodate multiple sets of stirring rods so arranged that any complete set of stirring rods can be removed and replaced while the apparatus is in operation, and so arranged that any individual stirring rod can be removed and replaced while the apparatus is in operation.

A further object of the invention is to provide stirring apparatus having an associated storage rack for supporting the stirring rods in a convenient manner when not in use and in a position which is properly arranged and accessible for easy removal to operating position.

Another object of the invention is to provide stirring apparatus which is designed so that it can be easily constructed in various sizes to accommodate any desired number of test tubes, and which is designed to be easily and conveniently sterilized.

By way of brief description, a stirring apparatus according to the invention comprises a container for receiving a liquid. Means are provided for supporting test tubes in side by side relation in fixed position in the container and arranged for partial emersion in the liquid. The liquid surrounding the test tubes is maintained at any desired temperature by means of conventional heater elements submerged in the liquid. The test tubes are arranged in multiple sets with the test tubes in each set arranged in a line and the multiple lines of test tubes are arranged parallel to each other. A stirring rod holding bar is provided for each set of test tubes, and a plurality of stirring rods are mounted on each holding bar in individually removable manner. The stirring rods are so positioned along each holding bar that when a holding bar is positioned over a line of test tubes each rod will project into a specific test tube. In a preferred embodiment there are four lines of test tubes and four holding bars. Two holding bar frames are provided, and each of these removably supports two of the four rod holding bars. The two frames are positioned above the test tubes so that when the rod holding bars are in place on the frames the stirring rods will project into the test tubes. Means are provided for driving each of the two frames in a path of motion which will cause the individual stirring rods to provide a continuous stirring motion in their respective test tubes. The driving means cause the two frames to move in exactly opposite directions so that there is substantially no vibration. A supporting rack is mounted on the apparatus for receiving the holding bars in parallel positions similar to the position they occupy in the two frames, and additional indexing means are provided to enable an operator to be certain of always placing each bar in exactly the same position on the same one of the two frames.

The various objects and features of advantage will become more apparent from the following detailed description wherein reference is made to the accompanying drawings in which:

FIGURE 1 is a perspective view of the stirring apparatus with three of the four rod holder bars in operating position and one of the bars in storage position on the supporting rack;

FIGURE 2 is a cross sectional view of the apparatus taken on the line 2—2 of FIGURE 1;

FIGURE 3 is a top view of the apparatus taken on the line 3—3 of FIGURE 2;

FIGURE 4 is a cross sectional view on enlarged scale showing a detail of the driving mechanism as seen on line 4—4 of FIGURE 3, but with the driving sprocked rotated 90° from the position in FIGURE 3; and

FIGURE 5 is an enlarged cross sectional view on line 5—5 of FIGURE 2 showing the means for removably holding the stirring rods adjustably positioned in the rod holders.

Referring in more detail to the drawings the stirring apparatus comprises a container **1** having sides **2–5** and a bottom **6** all interconnected in a fluid tight manner so that the container can be filled to a desired level with water. In order to heat water in the container and maintain it at a desired temperature, a plurality of immersion type electric heaters **8** are provided inside the container, two such heaters being shown in FIGURE 2. The heaters are mounted on insulating blocks **9** which are secured to the container walls **3** and **5**, with the heaters projecting through the walls in a conventional liquid sealed manner. The temperature of the heaters and therefore the temperature of the water in the container is controlled by a conventional thermostat **10** through which the current to all of the heaters passes.

A plurality of test tubes **14** are removably supported in the container **1** in vertical side by side arrangement. It is to be understood that the term test tube as used herein and in the claims broadly defines any shape of open top container for liquid to be mixed. The test tubes **14** are supported on an inverted U-shaped metal member **15** and are held in vertical arrangement by means of a second inverted U-shaped metal member **16** and a cover plate **17** at the top of the container. In a preferred embodiment the metal members **15** and **16** are made of a perforated stainless steel screening material which provides ample holes for circulation of heating water in the container. The side legs of the bottom member **15** are of course slotted where they extend over the heaters **8** in order to avoid direct metal contact therewith. In addition to the normal screen holes in the member **16**, it is further provided with large holes which receive and position the individual test tubes. Similarly the cover plate **17** is provided with holes which receive and position the test tubes. The guiding holes in plate **17** are of course vertically aligned with the holes in the metal member **16**. As will be seen best from FIGURE 3 the aligned holes in members **16** and **17** provide for the reception of four sets **20–23** of eight test tubes each, with the eight test tubes in each set being arranged side by side in a straight line. The cover plate **17** can of course be screwed to the tops of the sides of the container **1**, but it has been found convenient for removal and replacement simply to position the cover plate by the force of gravity. The cover plate is provided with a downwardly projecting rim **24** which assures proper lateral positioning of the plate.

In order to accomplish continuous stirring of liquids in the test tubes **14** a plurality of stirring rods **26** are provided. It should be understood that the term rods is employed herein and in the claims to define broadly any elongated mixing element or paddle in any appropriate specific shape. The rods **26** are mounted in four rod holders in the form of metal bars **30–33** which are in turn removably mounted on a pair of metal rod holder frames **34** and **35**. The rod holder frames are mounted on eccentric driving mechanisms which drive the rod holder frames in a continuous motion in a horizontal plane, as will be described hereinafter in more detail in connection with FIGURE 4.

The rod holder frames **34** and **35** are driven by a variable speed electric motor **38** which can be driven at any desired speed by means of a conventional Variac (not shown). The motor is held in place by a mounting bracket **39** which is secured to the wall **5** of the container and includes a hinged portion **40** which is spring biased away from the container and to which the motor **38** is directly connected. The drive shaft of the motor carries a sprocket **42** which in turn engages a conventional drive chain **43** which is maintained in proper tension by the outward biasing of the motor. The chain **43** passes around and drives four sprockets **46** as shown best in FIGURES 3 and 4. The sprockets **46** are mounted on the cover plate **17** and are positioned to form the four corners of a rectangle. Each of the sprockets **46** has a central recess containing a bearing **47** which is pressed in place in the recess. Each

bearing **47** surrounds a bearing retainer **48** which rests on the plate **17** and is held in place by a screw **49** through a second bearing retainer **50**. The screw **49** is concentric with the center of the sprocket **46**. A cap **51** is secured to the top of each of the sprockets **46** by screws **52**. Each cap **51** has an off-center boss **53** with a threaded hole therein to provide an eccentric driving axis formed by a screw **54**. Screw **54** passes through a bearing retainer **55** which engages a bearing **56** that is pressed into the respective rod holder frame **34** or **35**. The bearing arrangement **56** is covered by a disk **57** held in place by screws **58**. Other equivalent bearing arrangements can of course be used and the main point is that there be an eccentric drive between the sprockets **46** and the rod holder frames **34** and **35**. In order to achieve the non-vibrational feature of the apparatus, the eccentric drive axes **54** for one of the rod holder frames are arranged 180° out of phase with the drive axes **54** for the other rod holder frame. Thus, as shown in FIGURE 3 the axes **54** for rod holder frame **34** are positioned toward the bottom of the paper and those for frame **35** are positioned toward the top of the paper.

In order to provide a bearing surface on which the rod holder frames **34** and **35** can slide during the orbital motions caused by rotation of the sprockets **46**, a strip of bearing material such as Teflon is mounted along each of the long edges of the cover plate **17** as indicated at **60** and **61**. The Teflon strips **60** and **61** are provided with longitudinal grooves **63** as shown best in FIGURE 4 which receive and guide the drive chain **43**. Similarly Teflon bearing blocks or strips **64** and **65** are mounted on the ends of the cover plate **17**, and bearing block **65** is also provided with a chain receiving groove **63** as shown in FIGURE 2. The bearing blocks **64** and **65** are provided with upwardly projecting portions on which are mounted a protective cover strip **68** which serves also as a holder for a thermometer **69**. In a preferred embodiment nylon screws **70** are threaded in the cover strip **68** and bear against the top of the rod holder frames **34** and **35**. In order to complete the shielding and guiding system for the chain, a pair of slotted Teflon guides **72** are mounted on a ledge **73** which projects out from the upper end of the motor mounting bracket **39**. The shielding of the drive chain is completed by a protective cover plate **74**.

In order to support the rod holder **30–33** when they are not in use in the apparatus, a storage frame **76** is provided. The frame **76** is a U-shaped piece of metal with tabs **77** struck out of its upper side walls to provide recesses **78** for positioning and holding the rod holders when not in use. The storage rack **76** is secured in place by means of outwardly extending feet **79** which are screwed to the rear side wall four of the container **1**.

As shown best in FIGURE 5 the stirring rods **26** are vertically adjustable and individually removable from the rod holders **30–33**. In a preferred embodiment the rods **26** are frictionally held in place by means of a wire strip spring **82** positioned in a slot **83** in the side of the rod holder and pressed toward the holes for the rods by means of a screw **84**. As viewed in FIGURE 5 the stirring rod on the left has been removed, and it will be seen that the normal position of spring **82** partially closes the opening for the rod. Thus when a rod **26** is inserted into one of the rod holders it must force the spring **82** out of the way and is frictionally held in position by engagement by the spring. The arrangement is such that individual rods can be removed and or inserted even when the particular rod holder is in operation on a moving support frame **34** or **35**. It will be noted that one spring **82** serves each of two rods **26**.

In addition to being able to remove and replace individual rods during operation it is also possible to remove and replace an entire rod holder **30–33**. In order to provide this flexibility of adjustment, the rod holders are provided at their ends with detents as indicated in FIG-

URE 2, and the holder frames **34** and **35** are provided with spring biased balls **85** which engage the detents in a manner which holds the rod holders in place during operation but readily permits their insertion and removal. The holder frames **34** and **35** are provided with slots or recesses **86** which receive the ends of the holders and thus provide positive positioning against downward or sideways motion of the rod holders with respect to the holder frames.

It will be noted that in the same manner that four sets **20–23** of eight test tubes are provided, there is also provided a plurality of four matching sets of eight stirring rods each. The four sets of stirring rods are provided by the four rod holders **30–33**. In order to make it convenient and possible to be assured that each rod set **30–33** will always be positioned above its respective tube set **20–23**, the rack **76** is arranged to support the out of use rod holders in similar positions to those in which they are arranged in use. Thus it is convenient to always position the rod holder **33**, for example, always in the far slots on the supporting rack and in the far slots in the rod holder frame **35** as viewed in FIGURE 1, with the same end of the rod holders always pointing in the same directions. In addition to avoid any possible confusion, further indexing means are provided in the form of four different index marks **87–90** on one end of each rod holder, and corresponding index marks **91–94** adjacent each of the slots **85** in the rod holder frames **34** and **35**. Thus it is possible to be absolutely assured that when a rod holder is removed from its frame **34** or **35** and then replaced, the same end of the rod holder will always be in exactly the same position so that there will be no contamination from one set of test tubes to another, nor among tubes in any individual set.

Although specific details of the present invention are shown and described herein, it is to be understood that modifications may be made therein without departing from the spirit and scope of the invention as set forth in the appended claims.

What is claimed is:

1. Stirring apparatus comprising an open top container having side and bottom walls, a cover plate mounted on the top of said container, four sprockets rotatably mounted on said plate for rotation of each sprocket about its center, said sprockets being arranged to form the four corners of a rectangle, a drive motor having a drive sprocket, a drive chain interconnecting all five of said sprockets, two rod holder frames movably mounted above said plate in spaced side by side arrangement, bearing means connecting one of said holder frames to two of said four sprockets off-center of the axis of each of said two sprockets, bearing means connecting the other of said holder frames to the other two of said four sprockets off-center of the axis of each of said other two sprockets, the connections between said four sprockets and said two holder frames being so adjusted that when said four sprockets are rotated by said chain said two holder frames move in exactly opposite directions, at least one stirring rod holder mounted on each of said holder frames, at least one stirring rod mounted on each rod holder to project down into said container, and said cover plate being apertured to receive said stirring rods.

2. Stirring apparatus as claimed in claim **1** in which plastic bearing material is positioned between said cover plate and said holder frames.

3. Stirring apparatus as claimed in claim **2** in which grooves are provided in said bearing material to receive said chain.

4. Stirring apparatus comprising a container for liquid, means for supporting test tubes vertically in said container, two rod holder frames positioned above said container, at least one rod holder mounted on each of said holder frames, stirring rods mounted on said rod holders and arranged to project down into said test tubes, said rod holders being removably mounted on said holder frames, individual indexing means on each of said rod holders, matching indexing means on said holder frames whereby it is possible to be certain of always matching a specific stirring rod with a specific test tube, and means for driving said holder frames in opposite directions around closed paths of identical shape 180° out of phase with each other to cause said stirring rods to move inside said test tubes.

5. Stirring apparatus comprising a container for liquid, means for supporting test tubes vertically in said container, said supporting means comprising a plate adjacent the top of said container and provided with spaced holes for receiving test tubes, a partition wall above the bottom of said container having spaced holes for test tubes aligned with the holes in said plate, two rod holder frames positioned above said container, at least one rod holder mounted on each of said holder frames, stirring rods mounted on said rod holders and arranged to project down into said test tubes, and means for driving said holder frames in opposite directions around closed paths of identical shape 180° out of phase with each other to cause said stirring rods to move inside said test tubes.

6. Stirring apparatus comprising a container for liquid, means for supporting test tubes vertically in said container, two rod holder frames spaced from each other and positioned above said container, a protective strip covering the space between said holder frames, and a thermometer mounted on said protective strip and projecting down into said container, at least one rod holder mounted on each of said holder frames, stirring rods mounted on said rod holders and arranged to project down into said test tubes, and means for driving said holder frames in opposite directions around closed paths of identical shape 180° out of phase with each other to cause said stirring rods to move inside said test tubes.

7. Stirring apparatus comprising a container for liquid, means for supporting test tubes vertically in said container, two rod holder frames positioned above said container, at least one rod holder mounted on each of said holder frames, stirring rods mounted on said rod holders and arranged to project down into said test tubes, said rod holders being removably mounted on said holder frames, a rack on the side of each container shaped to hold said rod holders, and means for driving said holder frames in opposite directions around closed paths of identical shape 180° out of phase with each other to cause said stirring rods to move inside said test tubes.

8. Stirring apparatus comprising a container for liquid, means for supporting test tubes vertically in said container, two rod holder frames positioned above said container, at least one rod holder mounted on each of said holder frames, stirring rods mounted on said rod holders and arranged to project down into said test tubes, said stirring rods passing through holes in said rod holders, spring means frictionally engaging the side of each rod to hold it adjustably and removably in its respective hole, and means for driving said holder frames in opposite directions around closed paths of identical shape 180° out of phase with each other to cause said stirring rods to move inside said test tubes.

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